
COLUMBIA

ACCIDENT INVESTIGATION BOARD



Note: Volumes II – VI contain a number of conclusions and recommendations, several of which were adopted by the Board in Volume I. The other conclusions and recommendations drawn in Volumes II – VI do not necessarily reflect the opinion of the Board, but are included for the record. When there is conflict, Volume I takes precedence.

REPORT VOLUME III
OCTOBER 2003

On the Front Cover



This was the crew patch for STS-107. The central element of the patch was the microgravity symbol, μg , flowing into the rays of the Astronaut symbol. The orbital inclination was portrayed by the 39-degree angle of the Earth's horizon to the Astronaut symbol. The sunrise was representative of the numerous science experiments that were the dawn of a new era for continued microgravity research on the International Space Station and beyond. The breadth of science conducted on this mission had widespread benefits to life on Earth and the continued exploration of space, illustrated by the Earth and stars. The constellation Columba (the dove) was chosen to symbolize peace on Earth and the Space Shuttle Columbia. In addition, the seven stars represent the STS-107 crew members, as well as honoring the original Mercury 7 astronauts who paved the way to make research in space possible. The Israeli flag represented the first person from that country to fly on the Space Shuttle.

On the Back Cover



This emblem memorializes the three U.S. human space flight accidents – Apollo 1, Challenger, and Columbia. The words across the top translate to: "To The Stars, Despite Adversity – Always Explore"

The Board would like to acknowledge the hard work and effort of the following individuals in the production of Volumes II – VI.

Maj. Gen. John L. Barry	Executive Director to the Chairman
Dennis R. Jenkins	Investigator and Liaison to the Board
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Lt. Col. Patrick A. Goodman	Technical Editor
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Chapter 2	<i>Columbia's</i> Final Flight
Chapter 3	Accident Analysis
Chapter 4	Other Factors Considered
PART TWO	WHY THE ACCIDENT OCCURRED
Chapter 5	From <i>Challenger</i> to <i>Columbia</i>
Chapter 6	Decision Making at NASA
Chapter 7	The Accident's Organizational Causes
Chapter 8	History as Cause: <i>Columbia</i> and <i>Challenger</i>
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Appendix H.3	March 18, 2003	Houston, Texas
Appendix H.4	March 25, 2003	Cape Canaveral, Florida
Appendix H.5	March 26, 2003	Cape Canaveral, Florida
Appendix H.6	April 7, 2003	Houston, Texas
Appendix H.7	April 8, 2003	Houston, Texas
Appendix H.8	April 23, 2003	Houston, Texas
Appendix H.9	May 6, 2003	Houston, Texas
Appendix H.10	June 12, 2003	Washington, DC



Reader's Guide to Volume III

Volume III of the Report contains other technical documents produced by NASA and other organizations, which were provided to the Columbia Accident Investigation Board in support of its inquiry into the February 1, 2003 destruction of the Space Shuttle *Columbia*. The documents are compiled in the interest of establishing a complete record, but they do not necessarily represent the views of the Board. Volume I contains the Board's findings, analysis, and recommendations. The documents in Volume III are also contained in their original color format on the DVD disc in the back of Volume II.

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Volume III

Appendix E.1

CoFR Endorsements

This Appendix contains copies of STS-107 CoFR Endorsements and signature delegation authority letters.

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STS- 107 CoFR ENDORSEMENT		
ELEMENT	SERIAL NUMBER	PAYLOAD
ORBITER	OV-102	SPACEHAB RDM FREESTAR
ET	ET-93	SIMPLEX RAMBO
RSRM	RSRM-88	
SSME	2055, 2053, 2049	
SRB	BI-116	

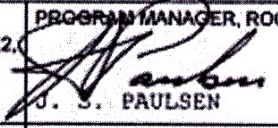
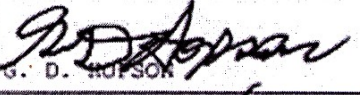
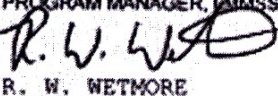

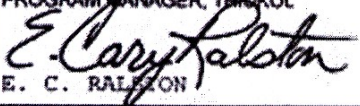
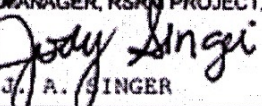
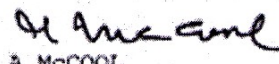
Projects having exceptions to this CoFR document are as follows (see Exception Log for details):

001 Orbiter

STS- 107 CoFR ENDORSEMENT

The Flight Preparation Process Plans documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities for each project (NSTS 08117, Section 8) have been or will be produced or completed.

- a. Certified flight hardware elements have been delivered to the SFOC at the Kennedy Space Center.
- b. Required hardware element processing specifications and requirements have been delivered to the SFOC.
- c. All identified "out-of-family" events that occurred after delivery of hardware for launch processing/ assembly/testing have been resolved.
- d. For "out-of-family" conditions detected during manufacturing, testing, or post-mission tear down and analysis, notification to the Space Shuttle Program has been made, and corrective action, if any, identified.
- e. The as-built flight element configuration satisfies the released requirements and engineering, based on data compiled and reviewed by SFOC.
- f. For the Space Shuttle Main Engine Project: Certified main engine controller software has been delivered for this mission.

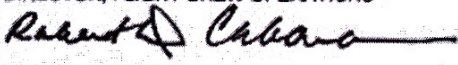
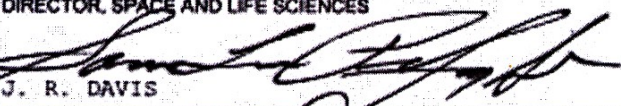
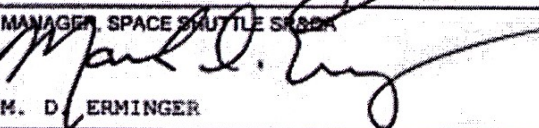
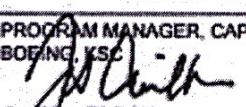

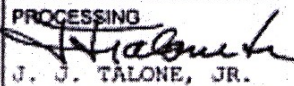
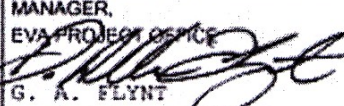
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ET (8.5.4.1, 8.5.4.2, Apx. D)	PROGRAM MANAGER, INISS  R. W. WETMORE	DATE 1/9/03	MANAGER, ET PROJECT, MSFC  J. W. SMELSER	DATE 1/9/03
RSRM (8.5.5.1, 8.5.5.2, Apx. E)	PROGRAM MANAGER, THSKOL  E. C. RALSTON	DATE 1/9/03	MANAGER, RSRM PROJECT, MSFC  J. A. SINGER	DATE 1/9/03
CONCURRENCE				
MSFC SHUTTLE PROJECTS	NA		MANAGER, MSFC SHUTTLE PROJECTS  A. A. MCCOOL	DATE 1/9/03

STS- 107 CoFR ENDORSEMENT

The Flight Preparation Process Plans documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities for each organization (NSTS 08117, Section 8) have been or will be produced or completed.

- a. For Payload Processing: Flight and ground requirements, payload logistics, and configuration requirements provided by the flight projects, have been maintained, performed, or are planned to be performed per approved TOPs.
- b. For EVA project: Audit, insight, and surveillance of SFOC activities have been completed or are planned for completion, and all discrepancies have been resolved. Oversight functions have been conducted in conjunction with Hamilton Sundstrand.

NASA

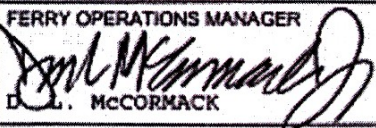
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SPACE AND LIFE SCIENCES <small>(8.5.15.1, 8.5.15.2, Apx. Q)</small>	DIRECTOR, SPACE AND LIFE SCIENCES  J. R. DAVIS	DATE 8/2/03
SPACE SHUTTLE SR&QA <small>(8.5.17.1, 8.5.17.2, Apx. Q)</small>	MANAGER, SPACE SHUTTLE SR&QA  M. D. ERMINGER	DATE 1/9/03
	CONTRACTOR	NASA
PAYLOAD PROCESSING <small>(8.5.10.1, 8.5.10.2, Apx. J)</small>	PROGRAM MANAGER, CAPPS BOEING, KSC  J. W. ELBON	DATE 1-9-03
EVA <small>(8.5.2.1, 8.5.2.2, Apx. B)</small>	PROGRAM MANAGER, HAMILTON SUNDSTRAND  C. SEABACK	DATE 1-9-03
	DATE 1-9-03	DIRECTOR OF ISS/PAYLOAD PROCESSING  J. J. TALONE, JR.
	DATE 1-9-03	MANAGER, EVA PROJECT OFFICE  G. A. FLYNT
		DATE 1-9-03

STS- 107 CoFR ENDORSEMENT

The Flight Preparation Process Plans documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities for each organization (NSTS 08117, Section 8) have been or will be produced or completed.

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NASA



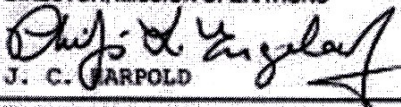
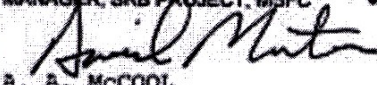
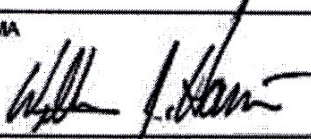


FLIGHT CREW OPERATIONS (8.5.11.1, 8.5.11.2, App. K)	DIRECTOR, FLIGHT CREW OPERATIONS R. D. CABANA	DATE
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SPACE SHUTTLE SR&QA (8.5.17.1, 8.5.17.2, App. Q)	MANAGER, SPACE SHUTTLE SR&QA M. D. ERMINGER	DATE
	CONTRACTOR	NASA
PAYLOAD PROCESSING (8.5.10.1, 8.5.10.2, App. J)	PROGRAM MANAGER, CAPPS BOEING, KSC J. W. ELBON	DATE DIRECTOR OF ISS/PAYLOAD PROCESSING J. J. TALONE, JR.
EVA (8.5.2.1, 8.5.2.2, App. B)	PROGRAM MANAGER, HAMILTON SUNDSTRAND C. SEABACK	DATE MANAGER, EVA PROJECT OFFICE G. A. FLYNT

STS- 107 CoFR ENDORSEMENT

The Flight Preparation Process Plans documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities (shared or independent) for each organization (NSTS 08117, Section 8) have been or will be produced or completed.

- a. The following NASA organizations have completed or plan to complete audit, insight, and surveillance of contractor activities, and have resolved all discrepancies.

NASA

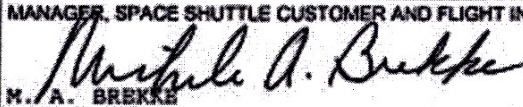
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SHUTTLE PROCESSING (8.5.8.1, 8.5.8.2, Apx. H)	DIRECTOR OF SHUTTLE PROCESSING, KSC  M. E. WETMORE	DATE 1-9-03
MISSION OPERATIONS (8.5.7.1, 8.5.7.2, Apx. G)	DIRECTOR, MISSION OPERATIONS  J. C. HARPOLD	DATE 1/9/03
SRB (8.5.6.1, 8.5.6.2, Apx. F)	MANAGER, SRB PROJECT, MSFC  A. A. MCCOOL	DATE 1/9/03
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STS- 107 CoFR ENDORSEMENT

The Flight Preparation Process Plans documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities (shared or independent) for each organization (NSTS 08117, Section 8) have been or will be produced or completed.

- a. The following NASA organizations have completed or plan to complete audit, insight, and surveillance of contractor activities, and have resolved all discrepancies.

NASA

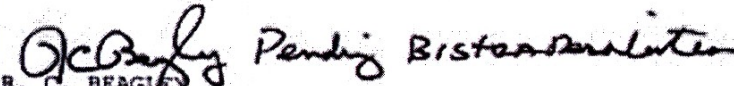
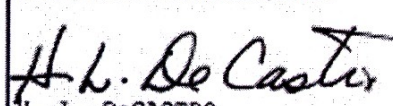
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SHUTTLE PROCESSING (8.5.8.1, 8.5.8.2, Apx. H)	DIRECTOR OF SHUTTLE PROCESSING, KSC M. E. WETMORE	DATE
MISSION OPERATIONS (8.5.7.1, 8.5.7.2, Apx. G)	DIRECTOR, MISSION OPERATIONS J. C. HARPOLD	DATE
SRB (8.5.6.1, 8.5.6.2, Apx. F)	MANAGER, SRB PROJECT, MSFC A. A. MCCOOL	DATE
SSP S&MA	MANAGER, SSP S&MA W. J. HARRIS	DATE
SYSTEMS INTEGRATION (8.5.13.1, 8.5.13.2, Apx. M)	MANAGER, SPACE SHUTTLE SYSTEMS INTEGRATION L. D. AUSTIN	DATE
VEHICLE ENGINEERING (8.5.1.1, 8.5.1.2, Apx. A)	MANAGER, SPACE SHUTTLE VEHICLE ENGINEERING R. R. ROE	DATE

STS- 107 CoFR ENDORSEMENT

The Space Shuttle Flight Preparation Process Plans (shared or independent) documented in NSTS 08117, Requirements and Procedures for Certification of Flight Readiness, have been satisfied. Required products and other responsibilities (shared or independent) for the SFOC (NSTS 08117, Section 8) have been or will be produced or completed.

- a. All out-of-family conditions have been identified and resolved with the NASA.
- b. The SSV has been processed in accordance with requirements and policies baselined by the SSP.

UNITED SPACE ALLIANCE

SFOC SQ&MA CONCURRENCE	VICE PRESIDENT, SAFETY, QUALITY AND MISSION ASSURANCE, SFOC  R. C. BEAGLEY	DATE 1/9/03
SFOC (8.5.18.1, 8.5.18.2, App. R)	SSP, PROGRAM MANAGER, SFOC  H. L. DeCASTRO	DATE 1/9/03

Boeing endorses that the requirements for CoFR documented in SSP 50108 and the Boeing Flight CoFR Implementation Plan have been satisfied in accordance with the Boeing specific responsibilities for this flight. Any issues that have arisen since the Stage Operations Readiness Review (SORR) have been resolved or have been presented at the Flight Readiness Review. This certification is subject to clause H.43 of NAS 15-10000 (for ISS Missions).

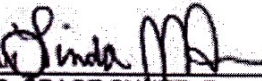
BOEING

ISS PRIME CONCURRENCE	VICE PRESIDENT AND PROGRAM MANAGER, ISS, BOEING N/A	DATE
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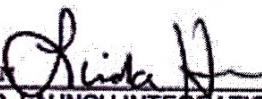
STS- 107 CoFR ENDORSEMENT

NASA SSP READINESS


The preparation of all Space Shuttle Program and Project organizations for this mission has been reviewed. All required processes, products, and responsibilities are complete or will be completed prior to launch. Deviations, exceptions or waivers have been reviewed and will be dispositioned by the Prelaunch MMT Review for this mission. The Space Shuttle Program is ready to proceed with the conduct of this mission.

L. J. HAN 
MANAGER, SPACE SHUTTLE
PROGRAM INTEGRATION

9 Jan 03
DATE

L. J. HAN 
MANAGER, LAUNCH INTEGRATION

9 Jan 03
DATE

R. D. DITTEMORE 
MANAGER, SPACE SHUTTLE PROGRAM

9 Jan 03
DATE

NASA ISS PROGRAM READINESS

All necessary activities required to support the flight, stage and increment have been accomplished or are planned. All deviations, waivers, and exceptions have been reviewed and satisfactorily dispositioned. The International Space Station Program is ready to proceed with launch and on-orbit operations. Any issues that have arisen since the SORR have been resolved or have been presented at the Flight Readiness Review (for ISS Missions).

N/A
MANAGER, INTERNATIONAL SPACE
STATION PROGRAM

DATE

CONCURRENCE

I concur that the Space Shuttle Program and the International Space Station Program (for ISS Missions) are ready to proceed with this mission.

M. C. KENNEDY 
DEPUTY ASSOCIATE ADMINISTRATOR FOR
INTERNATIONAL SPACE STATION AND
SPACE SHUTTLE PROGRAMS

9 Jan 2003
DATE

STS- 107 CoFR ENDORSEMENT

CONCURRENCE

As a member of the FRR Board, I concur that, pending completion of planned work, the Space Shuttle Program and International Space Station Program (for ISS Missions) are ready to execute this mission.

J. D. HOWELL

DIRECTOR, JOHNSON SPACE CENTER

DATE

R. D. BRIDGES

DIRECTOR, KENNEDY SPACE CENTER

DATE

A. G. STEPHENSON

DIRECTOR, MARSHALL SPACE FLIGHT CENTER

DATE

W. W. FARSONS

DIRECTOR, STENNIS SPACE CENTER

DATE

As a member of the FRR Board, I concur that, pending completion of planned work, the Prime Mission is ready to execute this mission (for non-ISS missions).

M. E. KICZA

ASSOCIATE ADMINISTRATOR FOR
PRIME MISSION

DATE

NASA S&MA has reviewed the status of preparations for this mission and has performed an independent assessment of the readiness of the Space Shuttle Program for the conduct of this mission, and the readiness of the International Space Station for launch and on-orbit operations (for ISS missions). We are in concurrence with proceeding with this mission.

B. D. CONNOR

ASSOCIATE ADMINISTRATOR, SAFETY AND
MISSION ASSURANCE

DATE

APPROVAL

The FRR Board has conducted a comprehensive assessment of the readiness of all flight and ground systems and supporting personnel. For ISS missions, the FRR Board has also conducted a comprehensive assessment of the readiness of the Launch Package/Cargo Element (LP/CE), ground hardware/software support facilities and personnel to support the flight, stage and increment including the readiness of the on-orbit stage to accept the LP/CE and return items. The Certificate of Flight Readiness has been endorsed by each program element. I have concluded, with the concurrence of the FRR Board, that pending completion of planned work, the Space Shuttle Program is ready to execute this mission and the International Space Station Program is ready for launch and on-orbit operations (for ISS missions).

W. F. REAGAN

ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT
(CHAIR, FRR BOARD)

DATE

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696



January 7, 2003

Reply to Attn of: SA-03-001

TO: John F. Kennedy Space Center
Attn: MK/Manager, Launch Integration

FROM: SA/Director, Space and Life Sciences

SUBJECT: Certificate of Flight Readiness (CoFR) Signature Authority

I authorize SA/Sam Pool and SD/Craig Fischer to have full signature authority to sign the Space and Life Sciences Flight Readiness Review of CoFR statement for STS-107 and subsequent flights.

A handwritten signature in dark ink, appearing to read "Jeff R. Davis, M.D.", with a stylized flourish at the end.

Jeffrey R. Davis, M.D.

cc:
SA/J. Davis
SA/S. Pool
SD/C. Fischer

AK91-T012-JWE-M03002
7 January 2003

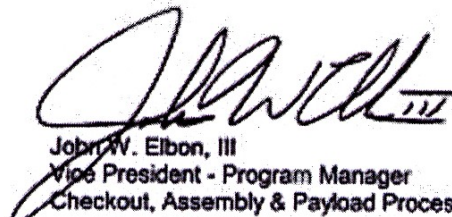


MEMORANDUM

Subject: **DELEGATION OF AUTHORITY FOR STS-107 CoFR**
To: **MK / Manager Launch Integration**

As my representative, Mr. James H. Chilton is delegated signature authority for the CoFR for STS-107 and for subsequent flight CoFR signature requirements when he attends as a representative of this office.

Please advise this office if additional information is required. Thank you.



John W. Elton, III
Vice President - Program Manager
Checkout, Assembly & Payload Processing Services
pb

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696



January 9, 2003

Re: DA8-03-004

DA8-03-004

TO: MK/Manager, Launch Integration
FROM: DA/Director, Mission Operations
SUBJECT: Certificate of Flight Readiness (CoFR) Signature Authority

This is to inform you that N. Wayne Hale's signature for CoFR signature authority has been revoked and the following individuals are delegated signature authority for any applicable Level I Certificate of Flight Readiness requiring Mission Operations Directorate endorsement.

DA8/J. Milton Hefflin	(281) 483-5428	Fax: (281) 483-3304
DA8/Robert E. Castle	(281) 483-0780	Fax: (281) 483-3304
DA8/Phillip L. Engelauf	(281) 483-4416	Fax: (281) 483-3304

A handwritten signature in black ink, appearing to read "Jon C. Harpold".

Jon C. Harpold

cc:
AB/B. R. Stone
AC/S. H. Garman
CA/R. D. Cabana
DA8/S. J. Elsner
DA8/J. M. Hefflin
DA8/R. E. Castle
DA8/P. L. Engelauf
DA8/N. W. Hale
DF/R. N. Fitts
DL/L. J. Ulljohn
DM/R. C. Epps
DO/L. D. Davis
DT/P. J. Beauregard
DV/J. Knight
DX/R. D. Dell'Oso
EA/F. J. Benz
MA/R. D. Dittmore
QA/W. H. Gerstenmaier
SA/D. R. Williams

COLUMBIA
ACCIDENT INVESTIGATION BOARD

National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812



Reply in Attn of MP01

OCT 16 2001

TO: Kennedy Space Center
Attn: MK/James D. Halsell

FROM: MP01/A. A. McCool

SUBJECT: Designation of MSFC Representatives to Space
Shuttle Readiness Reviews

The enclosed matrix is updated, designating individuals
authorized to represent their respective organizations at
the various readiness reviews.

A. A. McCool
A. A. McCool
Manager, Space Shuttle Projects Office

Enclosure

cc:
MP01/Mr. Clever
MP21/Mr. Hopson
MP31/Mr. Smelser
MP41/Mr. Martin
MP51/Mr. Rudolphi
MP71/Ms. Martin
JSC/MA/Mr. Dittmore

Mission Success Starts with Safety

**MSFC SHUTTLE PROJECTS REPRESENTATIVES TO SPACE SHUTTLE READINESS
REVIEWS**

<u>OFFICE</u>	<u>ET/SRB MATE</u>	<u>ORBITER ROLLOUT</u>	<u>ERB</u>	<u>L-1 & 2 MMT</u>
SPACE SHUTTLE PROJ. MGR	A. A. MCCOOL W. W. CLEVER* J. A. SINGER*	A. A. MCCOOL W. W. CLEVER* J. A. SINGER*	A. A. MCCOOL W. W. CLEVER* J. A. SINGER*	A. A. MCCOOL W. W. CLEVER* J. A. SINGER*
ET PROJECT MGR, MSFC	J. W. SMELSER T. F. GREENWOOD* N. OTTE*	N/A	J. W. SMELSER T. F. GREENWOOD* N. OTTE*	J. W. SMELSER T. F. GREENWOOD* N. OTTE*
SRB PROJECT MGR, MSFC	D. M. MARTIN J. L. LUSK*	N/A	D. M. MARTIN J. L. LUSK*	D. M. MARTIN J. L. LUSK*
RSTIM PROJECT MGR, MSFC	M. U. RUDOLPHI R. K. BURT* S. F. CASH*	N/A	M. U. RUDOLPHI R. K. BURT* S. F. CASH*	M. U. RUDOLPHI R. K. BURT* S. F. CASH*
SSME PROJECT MGR, MSFC	N/A	G. D. HOPSON A. E. GOLDMAN* A. L. WORLUND*	G. D. HOPSON A. E. GOLDMAN* A. L. WORLUND*	G. D. HOPSON A. E. GOLDMAN* A. L. WORLUND*

* ALTERNATE REPRESENTATIVE

ENCLOSURE (REVISED 10/18/01)

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696



Reply to item of: MS2-00-057

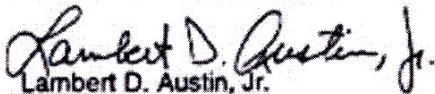
SEP 20 2000

TO: John F. Kennedy Space Center
Attn: MK/Manager, Launch Integration Office

FROM: MS/Manager, Space Shuttle Systems Integration

SUBJECT: Delegation of Authority for Certificate of Flight Readiness (CoFR)

As my representative, Mr. Rodney O. Wallace is delegated signature authority for the CoFR for STS-92 and for subsequent flight CoFR signature requirements when he attends as representative of this office.


Lambert D. Austin, Jr.

cc:
MA/R. D. Dittmore
MA2/W. H. Gerstenmaier
MS/D. S. Noah
MS2/R. O. Wallace

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001



January 8, 2003

Reply to Attn of:

U

TO: MK/Manager, Launch Integration
FROM: U/Associate Administrator for Biological and Physical Research
SUBJECT: Delegation of Authority

Due to other exigencies, I will not be attending the STS-107 Flight Readiness Review. Mr. Richard Zwierko, of my senior staff, is delegated the authority to sign the Certificate of Flight Readiness, on behalf of Code U. Should you have any questions, I can be reached at (202) 358-0215.

A handwritten signature in cursive script, reading "Mary E. Kicza".

Mary E. Kicza

cc:
M/Mr. Readdy
KSC/MK/Ginny Kinslow

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696



December 16, 2002

Reply to AIN of: MA-02-082

TO: Distribution

FROM: MA/Manager, Space Shuttle Program

SUBJECT: STS-107 Launch Integration

We all join in congratulating the Space Shuttle Program Manager for Launch Integration, Col. Jim Halsell, on his new assignment as commander of the STS-120 mission, the capstone mission of the International Space Station (ISS) assembly effort. With the successful completion of STS-120, ISS core assembly will be complete. This mission is especially significant in that it represents the culmination of the challenges overcome and the amazing successes recorded in establishing this great international orbiting laboratory.

Col. Halsell will be shifting focus and momentum immediately in order to begin preparations for STS-120. Consequently, effective January 8, 2003, Ms. Linda Ham will assume all launch integration duties relating to STS-107 and subsequent flights until a successor to Col. Halsell is named and in place.

On behalf of the entire Space Shuttle Program, we extend our personal thanks and gratitude to Col. Halsell for his untiring efforts, leadership, and service.

A handwritten signature in black ink, appearing to read "RD Dittmore".

Ronald D. Dittmore

cc:
See List

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